

February 15, 1894.

Sir JOHN EVANS, K.C.B., D.C.L., LL.D., Vice-President and
Treasurer, in the Chair.

A List of the Presents received was laid on the table, and thanks
ordered for them.

The following Papers were read:—

- I. "On Certain Ternary Alloys. Part VIII. Alloys containing Aluminium, Cadmium, and Tin; Aluminium, Antimony, and Lead; or Aluminium, Antimony, and Bismuth." By C. R. ALDER WRIGHT, D.Sc., F.R.S., Lecturer on Chemistry and Physics in St. Mary's Hospital Medical School. Received January 8, 1894.

In Part VII* it has been shown that whilst cadmium can act as "solvent" metal towards either of the immiscible pairs—lead and zinc, bismuth and zinc—this is not the case when aluminium is substituted for zinc, because cadmium and aluminium (contrary to the usual statements in the text-books) are *not* miscible in all proportions, unlike cadmium and zinc. Accordingly, it becomes of interest to examine the behaviour of ternary metallic mixtures where cadmium and aluminium are the two immiscible metals, more especially when a "solvent" metal is employed also capable of use in similar fashion with the immiscible pairs, aluminium and lead, aluminium and bismuth, so as to trace out the effect of substituting cadmium for lead or bismuth. Such a solvent metal is *tin*; the volatility of cadmium, however, precludes the possibility of employing elevated temperatures above the boiling point of that metal (about 770° C.); but, thanks to the physical attraction of molten aluminium for cadmium (comparable with that of water for gaseous hydrochloric acid), it is possible to keep molten in long narrow crucibles metallic mixtures containing simultaneously aluminium and cadmium, without any material amount of volatilisation of the latter metal taking place from the surface of the lighter alloy that floats up (of which aluminium necessarily constitutes the majority), so long as the

* Part I, 'Roy. Soc. Proc.,' vol. 45, p. 461; Part II, vol. 48, p. 25; Part III, vol. 49, p. 156; Part IV, vol. 49, p. 174; Part V, vol. 50, p. 372; Part VI, vol. 52, p. 11; Part VII, vol. 52, p. 530.

temperature does not exceed 700° to 750° . At temperatures of 800° and upwards, however, so much cadmium vapour is given off from the heavier alloy (in which cadmium predominates) as seriously to interfere with the experiment, not only because of the alteration in composition thereby produced, but also because of the intermixing effect tending to prevent proper separation by gravitation of the lighter and heavier alloys from one another.

Binary Alloys of Aluminium and Cadmium.

A series of observations was first made to determine the composition of the binary alloys formed when aluminium and cadmium are melted together and well stirred, and then allowed to stand at a temperature of 700 — 750° (averaging about 725°) for several hours. The following figures resulted as the averages from twelve tolerably concordant experiments:—

	Heavier alloy.	Lighter alloy.
Cadmium	99.78	3.39
Aluminium	0.22	96.61
	100.00	100.00

Hence the solubility of cadmium in aluminium, like that of lead and of bismuth in the same metal, is but small; whilst the solubility of aluminium in cadmium, like that in lead or bismuth, is inconsiderable, thus—

Temperature.	Solvent.		Percentage.
800° C.....	Lead	Aluminium	= 0.07
870°	Bismuth ...	„	= 0.28
725°	Cadmium ..	„	= 0.22
800°	Aluminium	Lead	= 1.91
870°	„	Bismuth	= 2.02
725°	„	Cadmium	= 3.39

Mixtures of Aluminium, Cadmium, and Tin.

The alloys were prepared by melting the aluminium, then adding the tin, and finally the cadmium, well stirring as soon as the latter was fluid, pouring quickly into the red-hot clay test-tubes, and maintaining these at 700 — 750° (averaging about 725°) for from six to eight hours in the lead bath. The analysis was made by dissolving in hydrochloric acid solution containing nitric acid, diluting and precipitating with sulphuretted hydrogen, and separating the tin and cadmium sulphides by means of ammonium sulphide, the tin being

finally weighed as SnO_2 , and the cadmium as CdO . The filtrate from the sulphides was precipitated by ammonia, the weight of the Al_2O_3 finally obtained being corrected for traces of iron and silica present. As in all previous experiments, the percentages were calculated on the sum of the weights of the three metals found as 100.

The following average values were deduced from the examination of twelve compound ingots (twenty-four alloys).

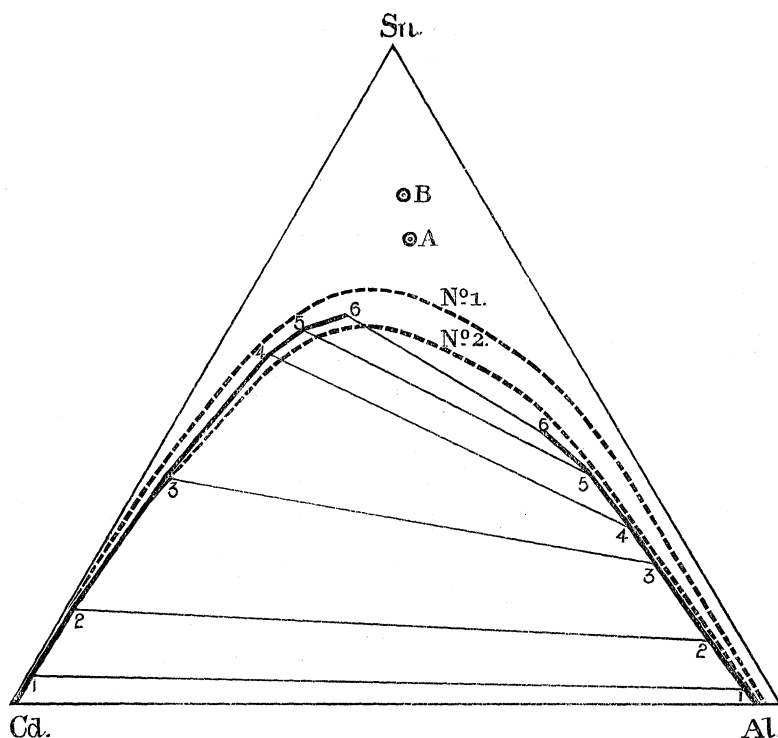
No. of tie-line.	Heavier alloy.			Lighter alloy.			Excess of tin percentage in lighter alloy over that in heavier.
	Tin.	Cadmium.	Aluminium.	Tin.	Cadmium.	Aluminium.	
0	0	99.78	0.22	0	3.39	96.61	0
1	4.75	94.84	0.41	2.75	4.45	92.80	- 2.00
2	14.78	84.70	0.52	9.98	4.93	85.09	- 4.80
3	35.98	61.49	2.53	22.28	5.78	71.94	-13.70
4	53.15	40.79	6.06	27.88	6.08	66.04	-25.27
5	57.28	34.26	8.46	37.07	8.18	54.75	-20.21
6	59.18	27.77	13.05	43.17	10.65	46.18	-16.01

Fig. 1 represents these values plotted on the triangular system, the dotted line No. 1 representing the curve obtained at 800° with aluminium-lead-tin alloys (Part VI), and No. 2 that similarly obtained with aluminium-bismuth-tin alloys. The points marked A and B represent two alloys that did not separate, containing respectively,

	Tin.	Cadmium.	Aluminium.
A	72.58	11.37	16.05
B	78.2	10.0	11.8

Obviously the effect of substituting cadmium for lead is to depress the critical curve; it cannot, however, be said with certainty that the same remark applies to the substitution of cadmium for bismuth, although this is probable; for the cadmium curve, being obtained at 725° , is not directly comparable with the bismuth curve obtained at 800° ; were the former obtainable with accuracy at 800° , it would doubtless be considerably depressed as compared with the curve at 725° , and would consequently probably lie wholly inside the bismuth curve at 800° ; even as it is, the right-hand branch lies inside. In confirmation of this, experiments now in progress with aluminium-cadmium-silver alloys indicate that the critical curve for these alloys lies well inside that with aluminium-bismuth-silver alloys.

FIG. 1.



As regards the direction of slope of the tie-lines, it is noticeable that they are similar in this respect to those obtained with aluminium-bismuth-tin alloys, always sloping downwards to the *right* (*i.e.*, the heavier alloy containing a larger proportion of "solvent" than the conjugate lighter alloy); with aluminium-lead-tin alloys, the lower alloys exhibited a slope to the left, and the upper ones to the right, presumably owing to the formation of a definite compound of tin and lead (probably Pb_3Sn), no analogue of which appears to be produced with either bismuth and tin or cadmium and tin.

Alloys containing Aluminium and Lead (or Bismuth) as Immiscible Metals, and Antimony as Solvent.

It has been shown in Part VII that when antimony is used as solvent metal, zinc and lead (or zinc and bismuth) being the immiscible pairs, the series of conjugate alloys producible are exactly comparable in general characters with the previously described ternary alloys with tin or silver as solvent. Precisely the same remark

applies to the corresponding alloys where aluminium is used instead of zinc, with only this difference, that when the proportion of antimony present exceeds a certain amount the mixtures employed no longer remain completely fluid when kept for several hours at temperatures near 850° — 900° C.; more or less of the difficultly fusible antimonide of aluminium, SbAl , described in Part VII,* separates out in the solid state; so that in certain cases where the proportion of antimony is large enough to form a "real" alloy a separation of the constituents still occurs in consequence of this action, the compound tending to float up through being lighter than the remaining fluid portion containing the whole of the lead. In consequence, the critical curve indicated by plotting as usual the compositions of the lowermost and topmost portions of the compound ingot ultimately obtained exhibits a sort of excrescence or horn in the central portion, where this abnormal separation occurs. A similar separation by solidification of aluminium antimonide is also observed in the case of alloys containing (in suitable proportions) aluminium, antimony, and some third metal miscible in all proportions with either of them separately; thus with zinc as the third metal, under proper conditions, solid aluminium antimonide separates, the fluid mother liquor, so to speak, consisting of the zinc, together with whatever aluminium or antimony may be present in excess, and such an amount of AlSb as this fused mixture of metals may be capable of permanently dissolving at the particular temperature of the experiment.

Mixtures of Aluminium, Lead, and Antimony.

The following average values were obtained on examination of twenty compound ingots (forty alloys), prepared by fusing together the weighed metals at a temperature above the melting point of silver, and well stirring, pouring into a nearly white-hot clay test-tube, and keeping this for six to eight hours in a lead bath at the highest temperature practicable with the appliances used. This temperature varied between about 850° and 920° , averaging near 880° ; even at the hottest, fragments of pure silver did not run down to a liquid, although they fritted together (melting point of silver near 950° C.). The analysis was made in the same way as that of the zinc-lead-antimony alloys described in Part VII, excepting that the acid filtrate from the precipitated sulphides of lead and antimony was directly neutralised with ammonia, the precipitated alumina being weighed, and corrections made for small quantities of F_2O_3 and SiO_2 present.

* The existence of this definite compound, described by the author in the 'Journ. Soc. Chem. Industry,' 1892, p. 492, has been since confirmed by D. A. Roche ('Moniteur Scientifique,' 1893, p. 269), who appears to have been unacquainted with the previous work on the subject.

No. of tie-line.	Antimony.	Heavier alloy.		Lighter alloy.			Excess of anti-mony percentage in lighter alloy over that in heavier.
		Lead.	Aluminium.	Antimony.	Lead.	Aluminium.	
0	0	99.93	0.07	0	1.92	98.08	0
1	1.13	98.49	0.38	3.73	5.06	91.21	+ 2.60
2	5.31	92.61	2.08	14.21	10.90	74.89	+ 8.90
3	9.23	87.69	3.08	22.09	14.43	63.48	+ 12.86
4	15.01	80.05	4.94	30.55	18.32	51.13	+ 15.54
5	21.86	70.29	7.85	38.15	21.23	40.62	+ 16.29
6	27.68	61.68	10.64	47.53	21.83	30.64	+ 19.85
7	37.13	48.39	14.48	54.13	19.33	26.54	+ 17.00
8	44.17	43.05	12.78	55.58	17.70	26.72	+ 11.41
9	50.88	34.39	14.73	60.30	18.10	21.60	+ 9.42
10	53.95	29.50	16.55	62.95	19.15	17.90	+ 9.00

FIG. 2.

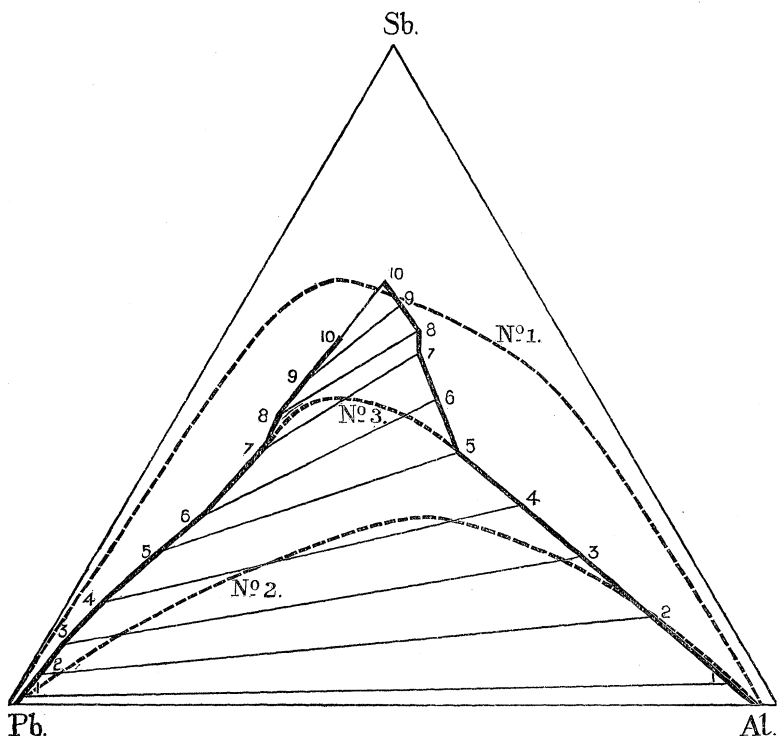


Fig. 2 represents these values depicted graphically on the triangular system, the outer dotted line, No. 1, being the curve obtained with aluminium-lead-tin alloys at about 800° (Part VI), and the inner dotted line that for zinc-lead-antimony alloys at 800° (Part VII). Obviously, the first five tie-lines belong to a perfectly regular curve, which, by analogy with the other two dotted curves, might be expected to follow approximately the course indicated by the middle dotted line No. 3; so that the tie-lines 8, 9, and 10 doubtless represent simply the effect of the separation of *solid* aluminium antimonide from what would otherwise be a "real" alloy, this action probably taking place partly during the period of tranquil fusion, and partly during the short time requisite to cool down the resulting compound ingot. In the case of tie-lines 6 and 7, the mixtures of metals used appear to have corresponded with ideal alloys, and the heavier alloys that were obtained did not widely differ from such as would be expressed by points on the normal critical curve; but this was not the case with the lighter alloys, where the quantities of aluminium

and antimony present relatively to the lead are abnormally increased through the formation of solid AlSb and its admixture with the fluid lighter alloy.

As regards the direction of slope of the tie-lines, it is noticeable that they all slope downwards to the left, as in the case of zinc-lead-antimony alloys. Obviously, the substitution of aluminium for zinc in these raises the critical curve, as in all other similar cases so far examined. On the other hand, the substitution of antimony for tin depresses the curve (so far as the normal portion is concerned, at any rate), just as in the case of zinc-lead-tin and zinc-bismuth-tin alloys.

Mixtures of Aluminium, Bismuth, and Antimony.

A parallel series of experiments with aluminium-bismuth-antimony alloys gave the following results as the averages from the examination of twenty-five compound ingots (fifty alloys). The analysis was made as in the case of zinc-bismuth-antimony alloys (Part VII), except that the acid filtrate from the precipitated sulphides of bismuth and antimony was precipitated with ammonia, the Al_2O_3 ultimately weighed being corrected for Fe_2O_3 and SiO_2 (p. 138).

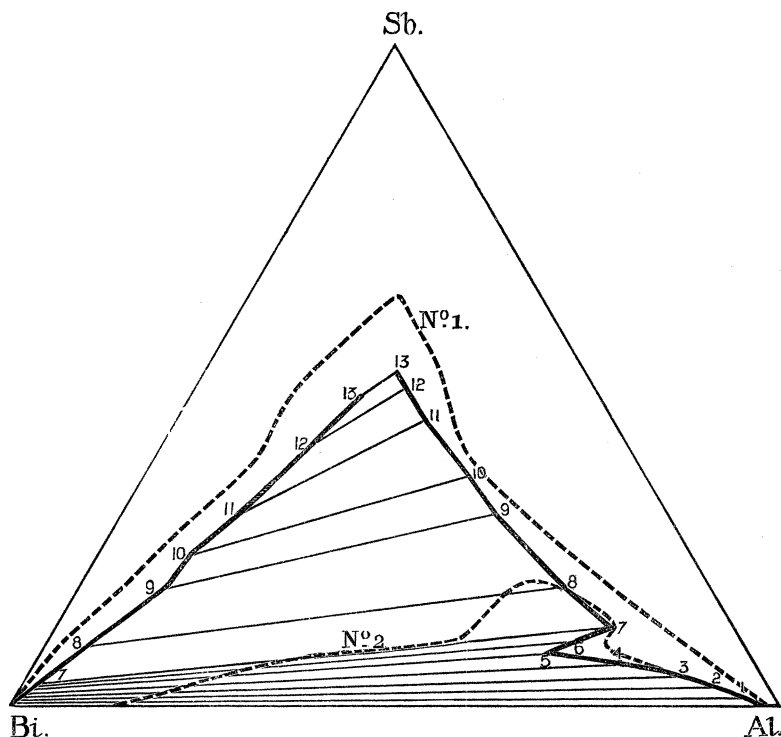
Fig. 3 represents these values plotted on the triangular system, the dotted line No. 1 representing the corresponding results obtained with aluminium-lead-antimony alloys, and the inner dotted line, No. 2, those obtained with zinc-bismuth-antimony alloys (Part VII). Obviously, the substitution of bismuth for lead depresses the critical curve, as usual; the uppermost portion shows precisely the same irregularity in the form of a central hornlike excrescence, due to the separation of solid SbAl , as was observed with aluminium-lead-antimony alloys; whilst the lower portion of the right-hand branch shows the same kind of sharply-marked inward depression as was previously observed with zinc-bismuth-antimony alloys, due to the formation of the definite compound of bismuth and antimony, Sb_2Bi_3 , aluminium (like zinc) being capable of dissolving this compound to a greater extent than mixtures of the two metals where one or the other predominates beyond this proportion.

	Calculated for Sb_2Bi_3 .	Found at position of maximum depression (5th tie-line).
Bismuth....	72.2	25.52 = 73.4
Antimony ..	27.8	9.26 = 26.6
	100.0	34.78 100.0

It is noticeable that the direction of slope of the tie-lines is the same as that with aluminium-lead-antimony alloys, downwards to the left; whereas with zinc-lead-antimony and zinc-bismuth-antimony the

No. of tie-line.	Antimony.	Heavier alloy.		Lighter alloy.			Excess of anti-mony percentage in lighter alloy over that in heavier.
		Bismuth.	Aluminium.	Antimony.	Bismuth.	Aluminium.	
0	0	99.72	0.28	0	2.02	97.98	0
1	0.50	98.31	1.19	1.30	4.61	94.09	+ 0.80
2	1.39	96.84	1.77	3.54	7.91	88.55	+ 2.15
3	1.25	97.22	1.53	5.57	9.65	84.78	+ 4.32
4	2.25	95.00	2.75	7.41	14.63	77.96	+ 5.16
5	3.16	93.83	3.01	9.26	25.52	65.22	+ 6.10
6	2.86	95.37	1.77	10.39	19.67	69.94	+ 7.53
7	3.35	94.10	2.55	10.81	15.48	73.71	+ 7.46
8	9.70	84.35	5.95	17.67	19.35	62.98	+ 7.97
9	17.48	70.22	12.30	29.58	22.08	48.34	+ 12.10
10	21.94	65.54	12.52	36.53	22.45	41.02	+ 14.59
11	30.49	53.65	15.86	43.55	24.59	31.86	+ 13.06
12	40.16	39.13	20.71	48.40	23.40	28.20	+ 8.24
13	46.66	29.87	23.47	50.50	23.90	25.60	+ 3.84

FIG. 3.



direction was reversed according as lead or bismuth was present, viz., downwards to the left in the first case, and to the right in the second.

II. "On the Photographic Arc Spectrum of Iron Meteorites."

By Professor J. NORMAN LOCKYER, C.B., F.R.S. Received December 22, 1893.

(Abstract.)

This communication consists of a discussion of the photographic arc spectra of the Nejed and Obernkirchen meteorites, the wavelengths of the lines being based upon those determined by means of the photographic arc spectrum of electrolytic iron, a paper concerning which has been recently communicated to the Society. The portion of the spectrum covered by the photographs extends from K to D.

FIG. 1.

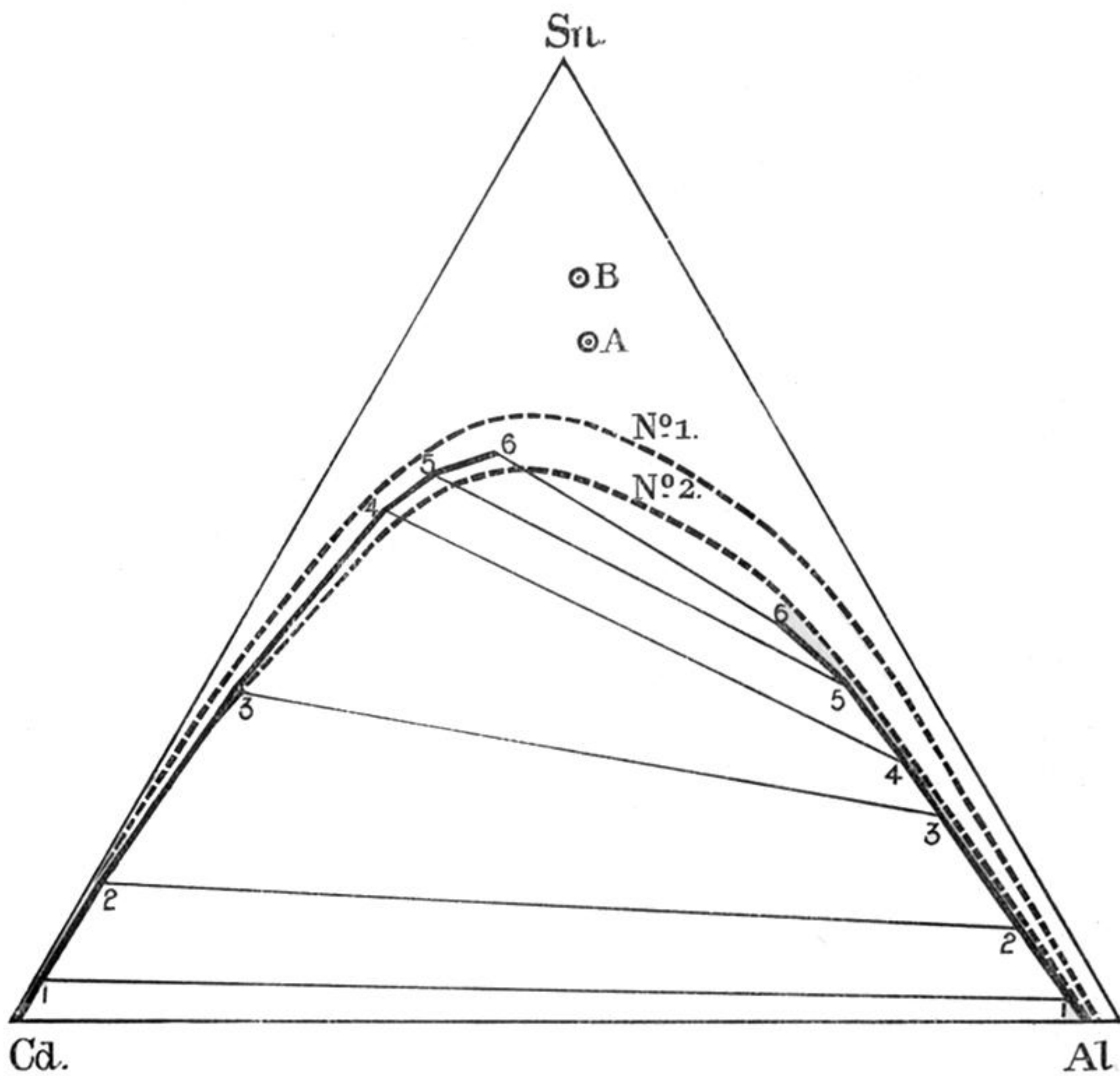


FIG. 2.

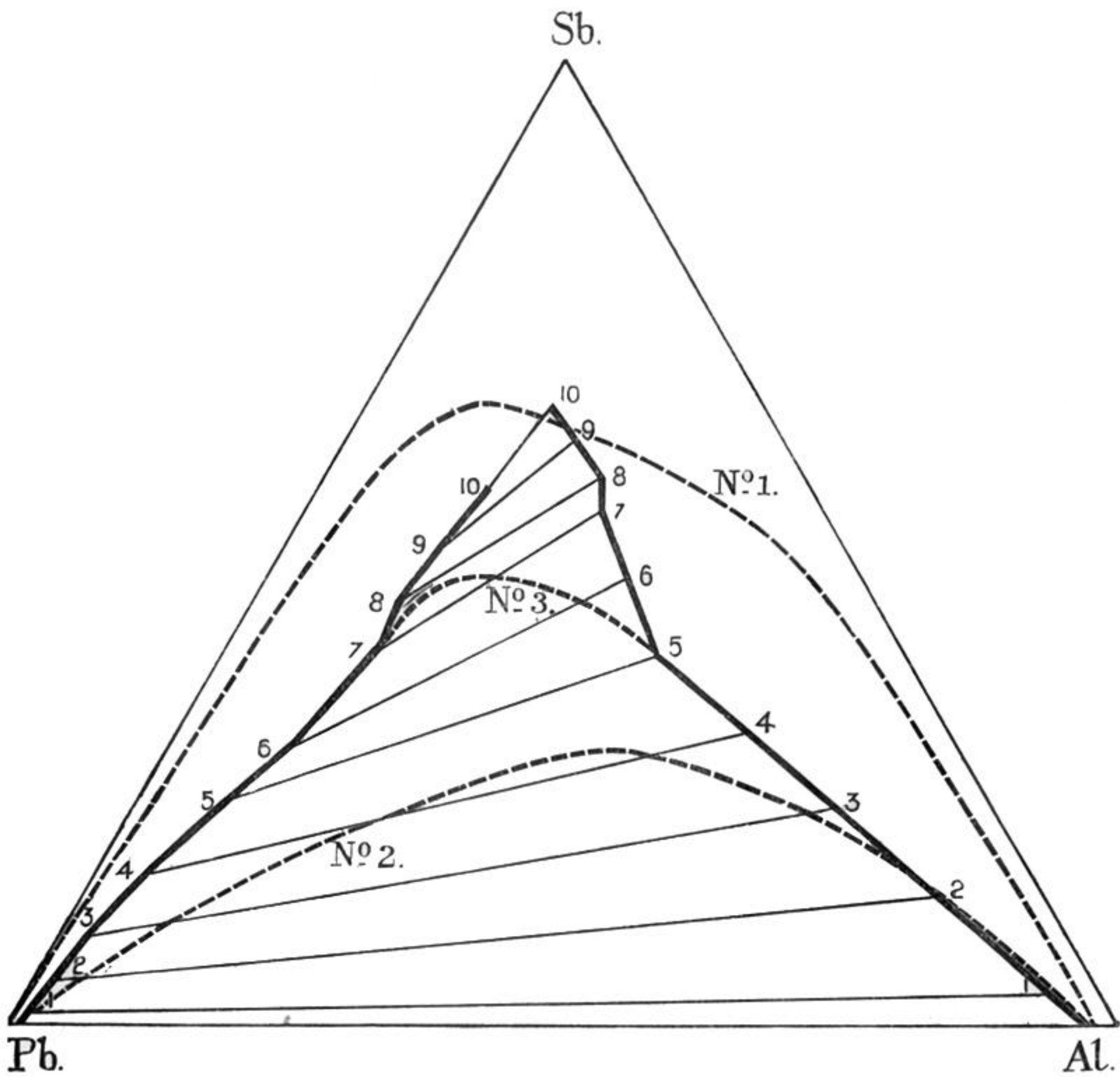


FIG. 3.

